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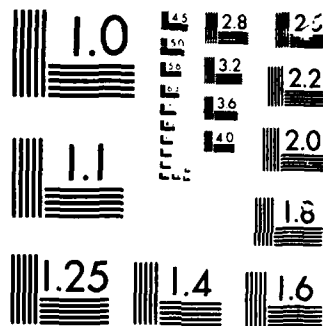
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The research conducted under this grant sought to explicate a model of human visual search activity and identify those variables that affect effective visual search. Concomitant with this goal it was possible to develop and enhance the hardware and software capabilities central to research in this area of visual information processing. This research has also addressed significant methodological issues in the analysis of eye movement data.		

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20. ABSTRACT CONTINUED

Over the course of the past three year effort considerable progress was made in meeting the stated research and development goals. Five major papers were published or are currently in progress that incorporate the results of the research and development efforts.

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## ARO Final Technical Report

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Leonard F.M. Scinto, R. Pillalamarri & R. Karsh - Cognitive strategies for visual search. Acta Psychologica, Vol. 62 (3), 1-30, 1986.

Leonard F.M. Scinto & Diane Barnette - An algorithm for determining clusters, pairs, or singletons in eye movement scan path records. Behavioral Research Methods, Instruments and Computers, 1986, 18 (1), 41-44.

R. Pillalamarri - Simulation of search on scenes with pre attentively non discriminable targets. Paper presented at the Fifth European Conference on Eye Movements. Paris, September, 1986.

Leonard F.M. Scinto - Selective attention during fixation and the discrimination of non pre attentively discriminable texture elements at various retinal locations. Applied Science Laboratories, (In Preparation).

R. Karsh & Leonard F.M. Scinto - The effects of stimulus repetition on strategies for visual search. (In Preparation).

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

Dr. David Sheena  
Dr. Leonard F.M. Scinto  
Mr. R. Pillalamarri  
Mr. Josh Borah  
Mr. Peter Cardia



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The research conducted under this grant sought to explicate a model of human visual search activity and identify those variables that affect effective visual search. Concomitant with this goal we also sought to develop and enhance the hardware and software capabilities central to research in this area of visual information processing. This research has also addressed significant methodological issues in the analysis of eye movement data.

Over the course of the past three year effort we have made considerable progress in meeting our stated research and development goals. Five major papers were published or are currently in progress that incorporate the results of our research and development efforts.

The following material presents an overview of our research activity for the past three years and documents the major experimentation under taken.

## I. Experiments on Visual Search:

### A. Visual Search for Pre attentively Non Discriminable Targets.

Beginning in the autumn of 1983 we began our central experiment on search for pre attentively non discriminable targets. The major finding from this experiment showed that with targets that are only detectable with what is termed in the literature controlled search, a serial process, subjects' search behavior as reflected in eye movement patterns was best characterized as random. On the basis of the data from this experiment we developed a simulation and model of search behavior for pre attentively non discriminable targets. Data from this experiment further demonstrated that psychometric measures of visual and spatial abilities were not good predictors of search performance. The model developed on the basis of these experiments led us to question certain assumptions current in the literature about the allocation of visual attention and the ability to discriminate texture patterns. These issues were explored in two later experiments in order to refine our model of visual search. These are described below under Retinal Mapping experiments.

### B. Search for Known and Unknown Targets.

One central issue that our initial experiment raised was the extent to which familiarity with targets (priming) might influence strategies for visual search. Using the same stimulus material as in our first experiment we tested for the effects of prior knowledge of target type (priming) on search behavior as measured by eye movements and scan paths. Data from this experiment confirmed our hypothesis that prior knowledge of target type and configuration did not affect search strategies in the case of pre attentively non discriminable targets. The data from this experiment showed that search behavior remained essentially a random process.

### C. Controlled and Automatic Search.

An experiment to assess the effects of stimulus repetition (practice) on visual search was run during 1985. The literature on visual search and visual attention allocation has posited two functional levels for the human visual system. The preattentive system which is able to rapidly discriminate targets from background elements in a visual display is associated with what has been termed automatic search. The non preattentive system which is responsible for allocating or directing focal attention for detailed scrutiny is associated with controlled search. Automatic search as the term suggests leads to automatic and effortless detection and identification of targets. The literature has suggested that controlled search, the purposive directing of visual attention for detailed scrutiny of elements in order for detection to take place, can be moved to automatic search through learning of the target set in a search task. If this were the case for texture elements that were initially pre attentively non discriminable then training should affect what we initially observed as near random search performance.

The data from our longitudinal experiment suggested that the process of controlled search for pre attentively non discriminable texture elements cannot be moved from control by the non preattentive system to the preattentive system. While practice did affect the overall search strategy subjects employed (subjects tended to optimize their search strategy) no improvement was observed in time to detect targets as predicted by the training model. There are clearly physiological limits imposed by the visual system itself. The implication here is that training cannot modify search strategies or improve performance where certain physiological constraints exist. In the case of search for pre attentively non discriminable texture elements the visual system is required to allocate focal attention in order to compute statistics of these texture elements beyond the second degree in order to make discriminations.

### D. Retinal Mapping Experiments.

Beginning in late 1985 and continuing into 1986 we undertook two series of experiments on retinal mappings. These experiments were designed to assess the degree to which visual information present to the eye during a fixational pause, some 260 msc. in duration, during a search task could effectively be processed by the allocation of focal attention and remain unaffected by retinal locus of that information. The information derived from these experiments is necessary to enhance the predictive accuracy of the search model we have been developing during the course of the research under this contract. Insights from these experiments will allow us to modify the treatment of the calculation of the probability of detecting a target texture element once it has been fixated during search.

The work by Bella Julesz and others at Bell Laboratories has suggested that there is no difference for detection of target texture elements in the

fovea and near periphery. Our series of experiments demonstrate that there are significant differences in the probability of detection and recognition of these elements if they appear in the fovea or near periphery. Overall these experiments demonstrated that retinal locus as well as texture type and orientation of the texture element were major factors in the probability calculation for detection of texture elements. The allocation of focal attention was not uniform across the fovea and near periphery. Recognition rates at three degrees from foveal center require more time for focal attention to scrutinize elements in order for recognition to take place.

The results from these experiments will be incorporated into the our search model. The data will be published in the paper entitled; "Selective attention during fixation and the discrimination of non pre attentively discriminable texture elements at various retinal locations" currently in preparation.

## II. Methodological Developments:

During the course of this contract we undertook several efforts at devising better analytic techniques to assess eye movement data, in particular scan paths.

We published one paper in this area that detailed an algorithm for detecting clusters, pair or singletons in scan path data. This algorithm provides an easy and accurate means for assessing basic characteristics of the distribution of fixations over stimulus scenes during visual information processing tasks. This clustering algorithm allows us to assess the degree of processing time allocated to various parts of a visual display. It can characterize the visual information processing strategies used by subjects.

During the past three years of this contract we have explored the possibility of devising an analytic technique to characterize scan paths as to type and category. Several approaches we tried from taxonomic clustering schemes to type analysis and factor analytic approaches have proved unsuccessful leading only to negative results. We ran several experiments in this area but the data from these experiments have currently proved inconclusive in suggesting a reliable means for characterizing scan paths as to type. Most recently we have pursued spatial-point techniques which show some promise of success.

## III. Software Developments:

Several in house software developments were under taken during the course of this contract. Improvements were made in our data collection software (CAPTURE PROGRAM) and in our main data processing program (FIXATION).



These developments have resulted in more elegant and accurate data acquisition and processing routines. We devised a software controlled stimulus presentation scheme for our retinal mapping experiments. This program allows for a flexible means for presenting multiple stimulus elements by a variable number of slide projectors in different combinations and at different exposure rates. The program is also used to collect data on reaction time and does some preliminary processing of this data. This program has saved us many man hours of work in collecting and processing data. For our retinal mapping experiments we developed a program to draw retinal maps defining the retinal area in which discrimination of texture elements can take place with minimal error rates.

#### IV. Hardware Developments:

Throughout the life of this contract improvements and upgrades were being made to existing laboratory data acquisition and processing equipment. Major accomplishments include the installation of a tape drive unit for the eye movement recording equipment, the development of a second optical head for the eye movement tracking unit, a new CCD camera for the optical head as well as the installation of an extended head tracking module. Various software and hardware improvements were also made to the eye movement control unit and computer.

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Principal Research Psychologist

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